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AGRICULTURAL MEMORANDUM NO. 846

SHELTER FOR LAMBING IN A PENNINE VALLEY I

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1. BACKGROUND TO THE WORK

Studies of the economics of hill sheep flocks have shown that lamb deaths are an important cause of financial loss. An experiment began in 1978 at Great House Experimental Husbandry Farm, to study the behaviour of ewes at lambing and the causes of lamb deaths. The Meteorological Office at Harrogate is contributing by measuring the weather elements which lead to stress.

2. THE SITE

Great House is on the edge of a Pennine valley twenty kilometres North of Manchester. The valley is orientated SW-NE and closed at its SW end. The high ground on either side rises to about 350 m above mean sea level, and the valley floor which is just below the lambing field, Stone Law, is at 200 m above msl. Stone Law itself, which is an 'in bye' permanent pasture field of $2\frac{1}{2}$ hectares, enclosed by $1\frac{1}{2}$ m high dry stone walls, lies on the NW (SE facing) slope of the valley. (See Fig. 1)

There is a permanent weather station at one side of Stone Law at which daily measurements have been made since 1953.

3. EQUIPMENT

Heat loss from lambs is mainly controlled by temperature, wind speed and whether the animals' coat is wet, so equipment to measure temperature and wind speed was temporarily installed at 9 locations in the field, where significant differences from measurements made at the weather station were expected to be found. (See Fig. 2)

Cup counter anemometers, from which mean wind speeds may be calculated, were mounted on sturdy wooden posts so that the cups were 1 m above ground level. This height was chosen so as to be within the shelter of the stone walls, but not so near to the ground as to be subject to very local influences.

The measurements made at the weather station were supplemented by a Woelfle wind recorder, installed at a height of 2 m. This provided a continuous record of wind speed and direction on a clockwork driven paper chart.

Just below each cup counter anemometer, thermometers were mounted in 'cocoa tin'(1) screens, and a grass minimum thermometer was installed at Site 9.

These instruments were read at 0900, 1200 and 1500 GMT each day. The readings were commenced eleven weeks before the ewes were put into the field, to allow relationships to be developed between the measurements made at the weather station, and at the temporary sites. Then, during the actual lambing period, when for safety reasons the equipment at the temporary sites had to be removed, the wind pattern across the field could be inferred from measurements which continued to be made at the weather station.

4. STOCK

The pure bred Derbyshire Gritstone ewes, all of which had given birth before, spent most of their pregnancy on the hill slopes of Great House. They were brought to lower pastures three weeks before lambing, and moved to Stone Law a day or so prior to giving birth. Thirty three lambs, of weights normal for the breed, were born to twenty six ewes on Stone Law.

5. CALENDAR OF EVENTS AT STONE LAW

2 February 1978	Installation of cup counter anemometers and thermometers
7 February 1978	Start of run of wind and temperature measurements
7 March 1978	Installation of Woelfle Wind Recorder in enclosure Calibration check of all thermometers
19 April 1978	End of run of wind and temperature measurements Anemometers and thermometers removed from Sites 2-9
24 April 1978	Ewes transferred from farm to Stone Law
26 April 1978	8 lambs born (one found still born)
27 April 1978	9 lambs born (one found still born)
28 April 1978	6 lambs born
29 April 1978	7 lambs born
30 April 1978	2 lambs born
1 May 1978	No births
2 May 1978	1 lamb born
16 May 1978	Woelfle Wind Recorder removed from enclosure

6. ANALYSIS OF WIND DATA

First a test was applied to find how much the wind direction over Stone Law was modified by the general topography. Wind directions measured at the weather station during the period 19 March to 16 May were plotted against directions of the isobars taken from appropriate Daily Weather Reports, and the results are plotted in Fig. 3. This indicates surprisingly little influence of the valley orientation on the wind direction, nor does vertical stability of the air, insofar as it is indicated by the time of day, seem to have much effect.

Then, using the anemometer readings, mean wind speeds at 1 m were calculated for Sites 3-9, and expressed as a percentage of the average speed calculated for Site 2 (at 1 m) which was adjacent to the weather station. For each period between readings these percentages were plotted and showed that for occasions with similar wind directions the wind speed percentage patterns were also similar.

The wind speed percentages were therefore averaged by direction sectors, each of 60°, in such a way that one symmetrically straddled the SW-NE direction of the valley, and another included all direct down slope winds over Stone Law.

It will be seen from Fig. 4 that when blowing from the 210°-270° sector, the wind at Site 5 was 50% stronger than the wind at Site 2, whereas the wind at Site 9 was less than the Site 2 wind by 71%. The spatial variation of speed, the difference between the maximum and minimum wind percentages (referred to Site 2), was much less for down slope winds (Fig. 5) as it was for the sector shown in Fig. 4. This spatial variation is shown for all sectors in Fig. 6, and highlights the risk of using information from a single anemometer in this sort of terrain.

The wind speed and direction at each birth, plotted in Fig. 7, show that for much of the time during the lambing period, the wind was from the NE. The wind regime over Stone Law will, therefore, have been similar to that in Fig. 8. This shows that when the wind was NE-E the speed varied over the exposed parts of the field by only a few percent. Only the lowest parts of the field at Site 9, 3 and 4 experienced any marked reduction in speed. Most ewes sought the protection of the NE boundary wall to give birth, where no measurements of wind speed were made. To find what wind speeds they were likely to have experienced it is worth noting how symmetrical are the contours of the field on either side of the slight ridge that bisects it in the NW-SE direction. The walls on each side of Stone Law are of similar dimensions and of similar permeability. It is reasonable to suppose that they will each give rise to the same reduction in speed. From Fig. 4 it will be seen that when the wind is in the 210-270° sector the speed experienced at Site 3 is only 24% of that at the more exposed 'reference' Site 2. It is therefore assumed that the wind speed in the lee of the NE wall at 1 m was one quarter of the speed measured at Site 2 also at 1 m.

The relation between the wind speed at 2 m at Site 1, and the wind speed at 1 m at the adjacent Site 2 was calculated. This was used during the lambing period, when the 1 m anemometers were removed from the field, to reduce the wind speeds as measured by the Woelfle recorder at 2 m to a height of 1 m. This relation, compatible with a surface roughness z_o of about 1 cm (the grass length on Stone Law was 10-15 cm) was used to calculate the average further reduction in wind speed from the derived 1 m measurements to 'lamb height' which was taken to be 0.5 m. This last reduction was found to be about 20%.

Detailed Procedure

When calculating run of wind at each individual birth place, the 2 m Woelfle run of wind was reduced to 1 m. Then using the ratios in the appropriate sector diagram the run of wind at the nearest anemometer site was calculated. This was then reduced by 20% to find the wind at lamb height (for lambs born in the open field) and by a further 75% for lambs born in the shelter of the wall.

7. TEMPERATURE ANALYSIS

Throughout the measuring period air temperature differences between the nine sites on Stone Law were generally less than 0.5°C. Night time air minima averaged 0.5°C lower at Site 9 than at Site 2, and on only four occasions did the difference exceed 1.5°C.

The grass minima at Site 9 were on average however, about 4°C lower than those at Site 1, and the difference increased on six occasions of strong radiative cooling, to more than 7°C. The maximum difference measured was 8.9°C.

Weather observations were made only at 0900 GMT during the lambing period, but the wind strength for much of the time was such that temperature differences across the field would have been small. Maximum temperatures ranged from 6.7 to 10.1°C, and the minimum air temperatures ranged from 1.4 to 4°C with the exception of the 28th when the air minimum fell to 0.5°C. Grass minimum temperatures ranged from 2.0°C to 4.4°C, with the exception of the 28th when it was -1.6°C and the 29th when it was -0.1°C.

8. ASSESSMENT OF STRESS ON THE STONE LAW LAMBS

The ability of a lamb to maintain a normal body temperature will depend on its capacity to produce heat. This capacity, known as 'summit metabolism', which in normal lambs from adequately fed ewes can be up to five times the basal metabolic rate, has been measured in a climatic respiration chamber by Alexander.(2) In homeothermic animals, such as the young lamb, metabolic rate increases in response to an increase in heat loss so that the body temperature may be stabilised. Heat loss is increased when air

temperature falls and when air movement or evaporation from the coat increase. Thus it is possible to calculate for a lamb of a given weight, the temperature of its environment below which it is incapable of maintaining its body temperature and begins to succumb. This temperature, T_s, may be deduced from Fig. 9, in which lamb weight, state of coat, run of wind and T_s are related. eg. A 5 kg lamb with a wet coat in a daily run of wind of 350 miles/day has a T_s of $0^{\circ}C$. Accordingly the run of wind and the average air temperature were calculated for each day during the lambing period, and compared for T_s for each lamb.

9. LAMBING RESULTS

All lambs born alive on days when the run of wind was less than 200 miles, were capable of maintaining their normal body temperatures and survived. On the 26th, in a daily run of wind of 260 miles, the average air temperature was only $1.5^{\circ}C$ above the T_s of the lightest (3.3 kg) lamb of the crop, but it too survived.

On the 30th, however, the average air temperature was found to be about three degrees below the T_s for a pair of twins. One lamb survived without assistance but the other, whose temperature had fallen to $23.6^{\circ}C$ by the time of discovery, had to be taken to shelter, given warm feeds and wrapped in warm cloths to bring its temperature back to normal. Data for these twins are:-

Date	Miles Run of Wind 0001-2359	Average Air Temp. for day $^{\circ}C$	T_s of Lambs $^{\circ}C$	Weight of Lambs in kg	Born to Ewe No.
30 April 1978	440	+4.8	+8.0	1. 4.8 2. not recorded	B193 away from walls

10. CONCLUSIONS

From the lambing records and meteorological measurements made at Stone Law it has been possible to assess the thermal stress experienced by the lambs at each birth place. The lambing records confirm that the shelter afforded by the walls plays a large part in reducing heat loss, particularly when the animals coat is wet. In this work the shelter and warmth provided by the ewe have not been measured, but in the one recorded case of stress in a lamb born away from the wall, the presence of the ewe appears to have provided insufficient protection to maintain the lambs temperature.

11. RECOMMENDATIONS FOR FUTURE WORK

The normal meteorological measurements made at the weather station, plus the addition of the Woelfle wind recorder will be sufficient to make a general analysis of the wind and temperature patterns across Stone Law in next year's experiment. Provision of a continuous record of temperature including, perhaps, measurements made at lamb height close to a wall would help the calculation of relevant average temperatures.

The main uncertainty in calculating relevant wind speeds is in assessing the large effect of the sheltering dry stone walls. It is recommended that this should be studied on a flatter site than Stone Law, where the effect of the permeability of the walls may be separate from that of topography. If this can be done, then it will be worthwhile to measure the distance of each birth place from the wall.

In future years it is proposed to lamb earlier in order to improve the chances of observing lambs under stress. A study of past weather records from Great House could help to decide the best lambing date for this purpose.

12. ACKNOWLEDGEMENTS

The work done by Dr J R Starr during the planning of the experiment and the setting out of the equipment, together with the advice and background information of experience gained elsewhere is gratefully acknowledged, as is the working up of the data by Miss B Moss and the typing of the drafts by Mrs S Smith.

The loan of the Woelfle Wind Recorder by Dr C P E Longden of Broom's Barn Experimental Station, Bury St. Edmunds was much appreciated, and thanks are due to the Director of Great House EHF for advice on anemometer siting, to Miss E Midgley who recorded the lambing data and to Messrs W A Kneale, J P F Van Dyk and J M Hughes who, in the midst of their other work, made some six thousand individual meteorological readings.

Any comments or suggestions about this paper should be referred to the authors.

Meteorological Office
Harrogate
November 1978

References

1. Hurst G W — 1970 Agrometeorology in the Meteorological Office. Met. Mag 99, pp 170-177

2. Alexander G — 1964 Proceedings of the Australian Society of Animal Production. Vol 5, pp 113-122

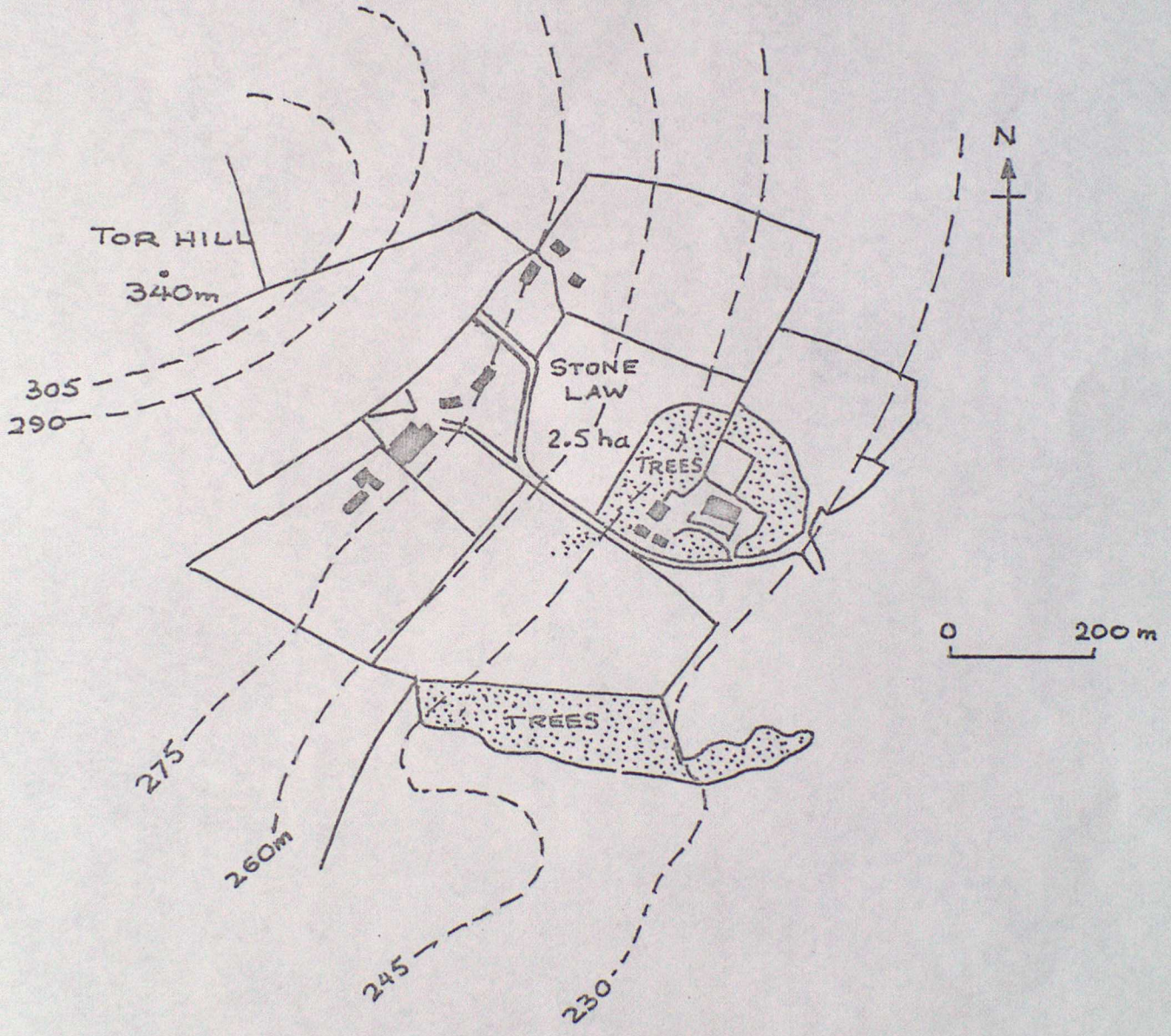


FIG. 1 - Part of Great House EHF showing Stone Law

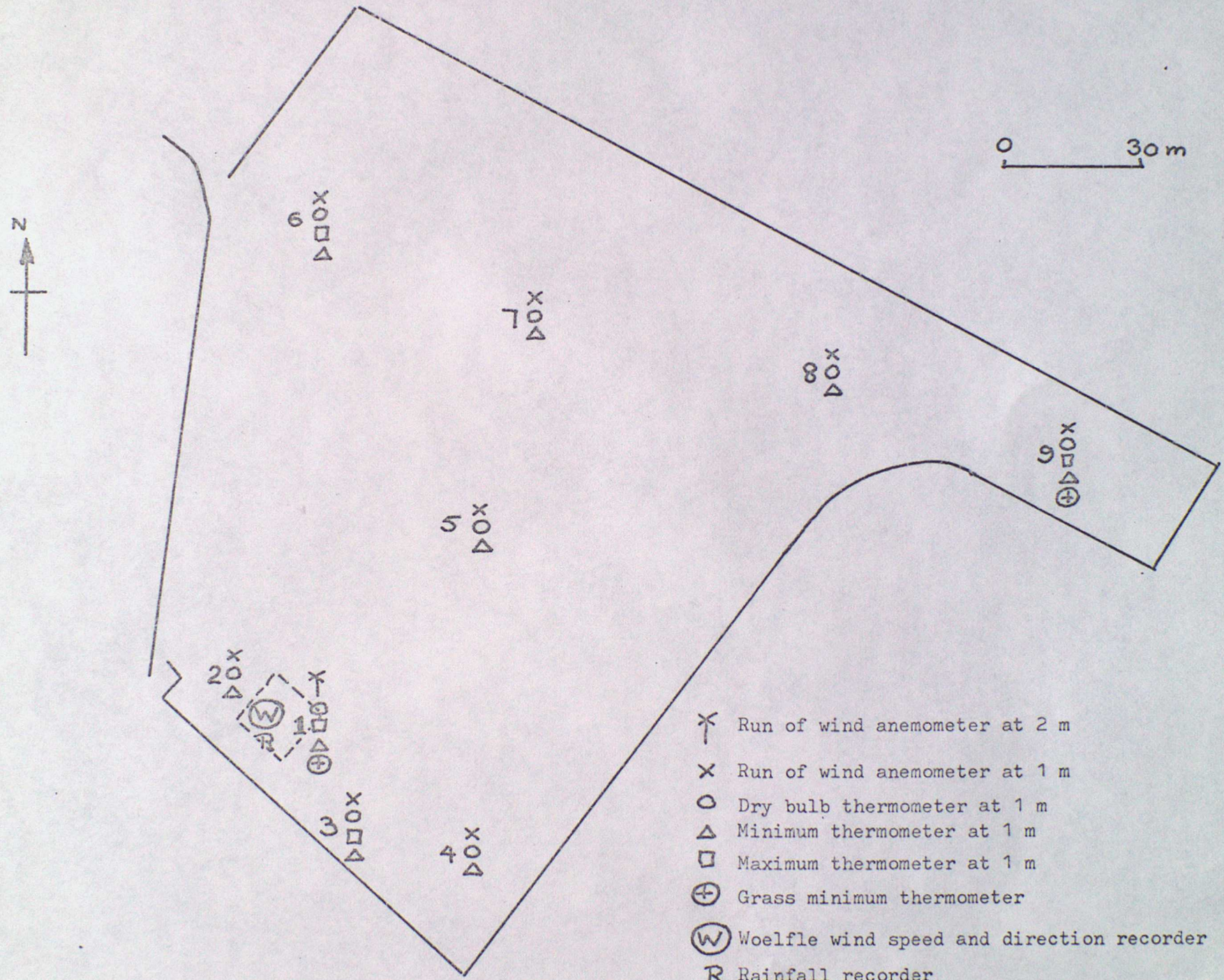


FIG. 2 - Disposition of Equipment on Stone Law

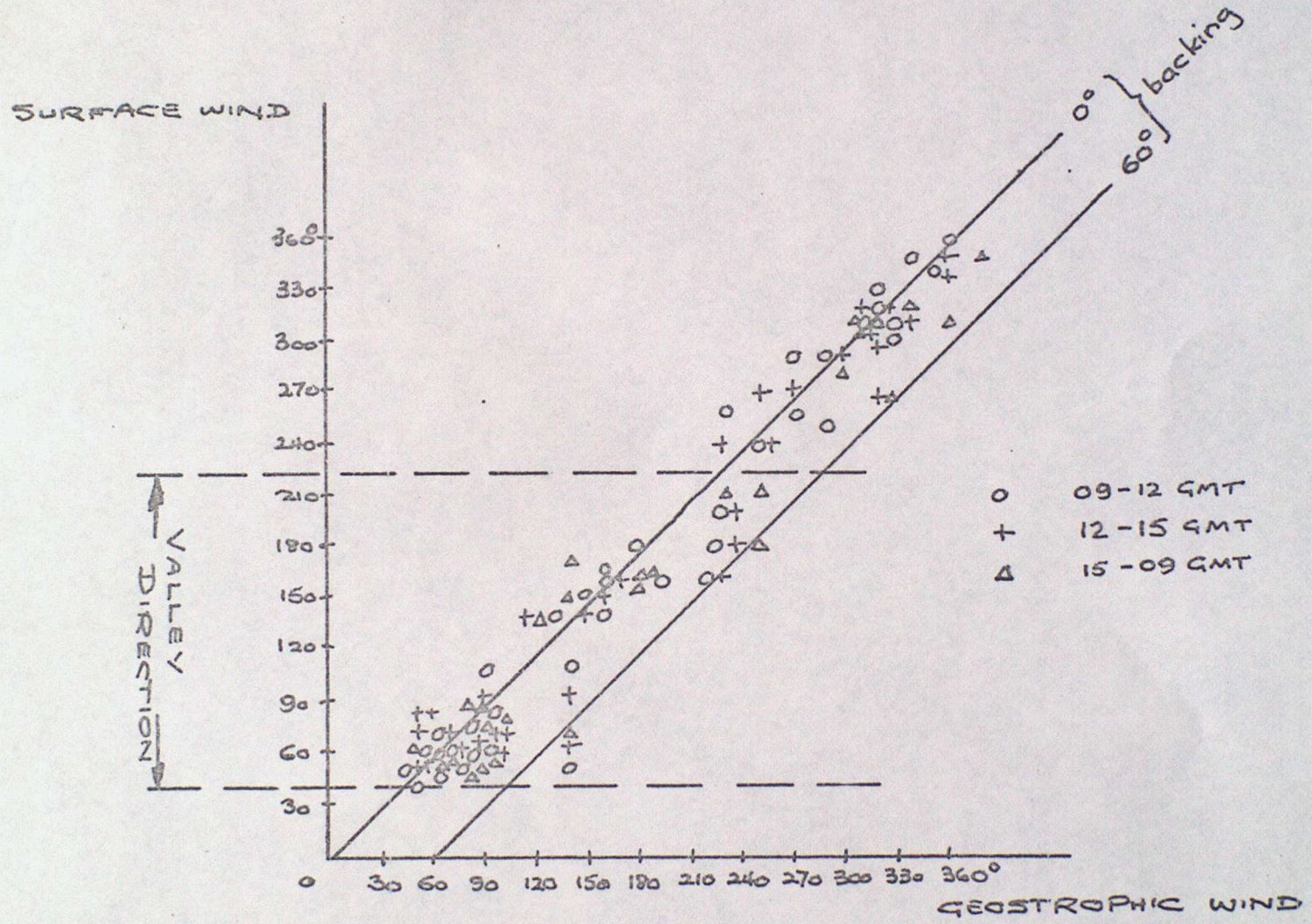


Fig. 3 - Showing Relation Surface Wind at Stone Law to Geostrophic Wind from DWR - Spring 1978

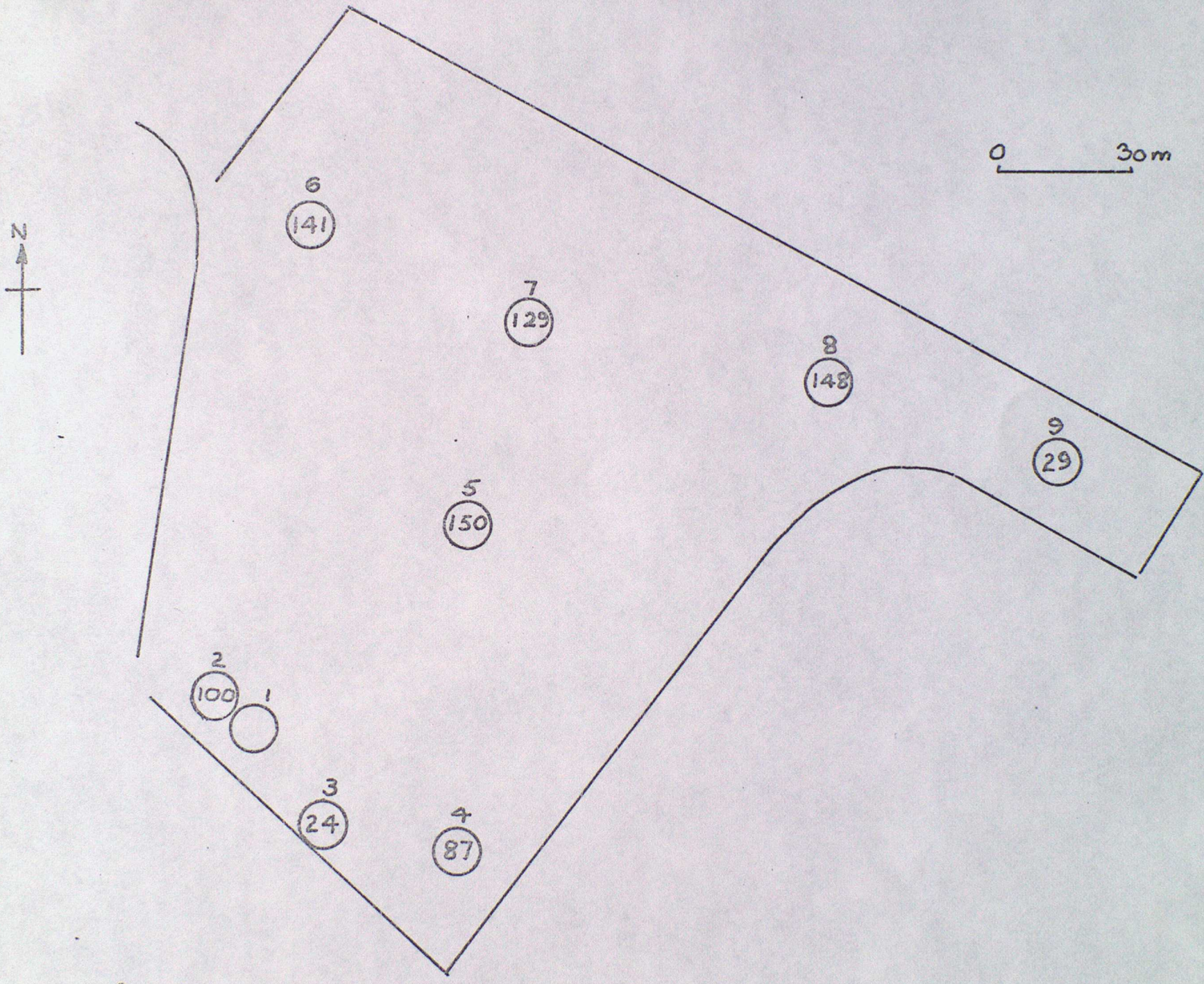


FIG. 4 - Wind from 210°-270° (at 1 m)

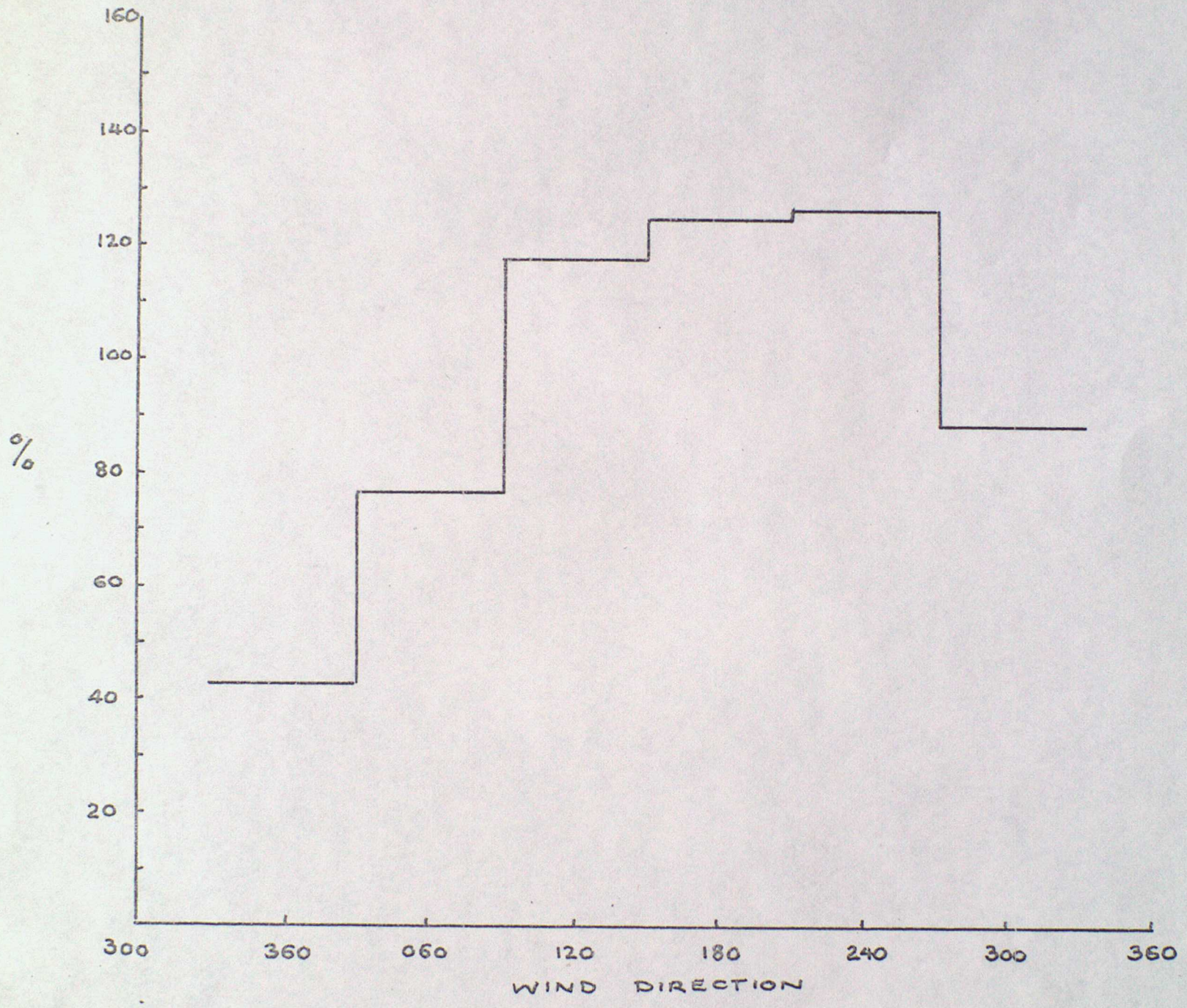


FIG. 6 - Spatial Variability of Mean Speed with Wind Direction at Stone Law

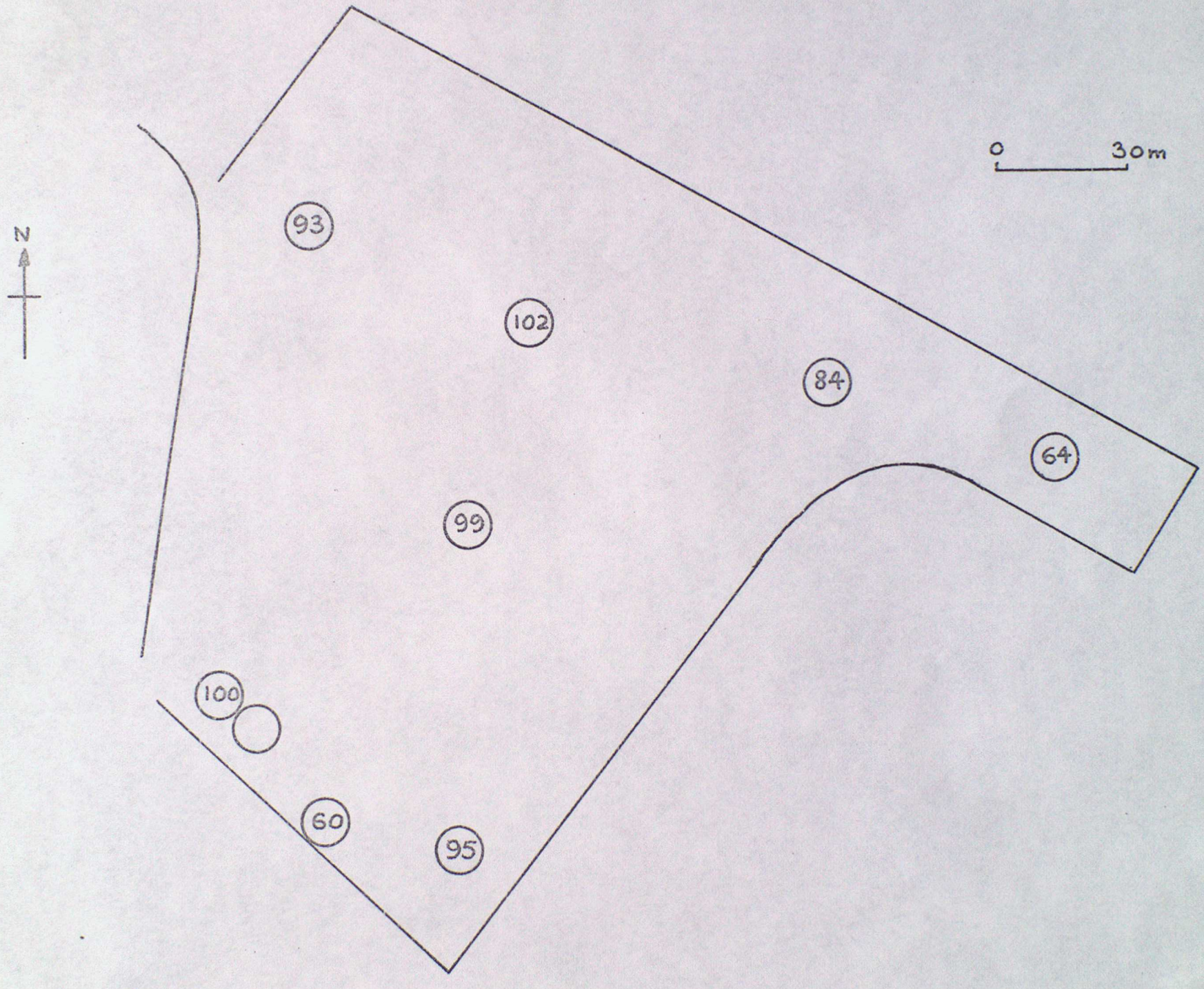


FIG. 5 - Wind from 330°-030° (at 1 m)

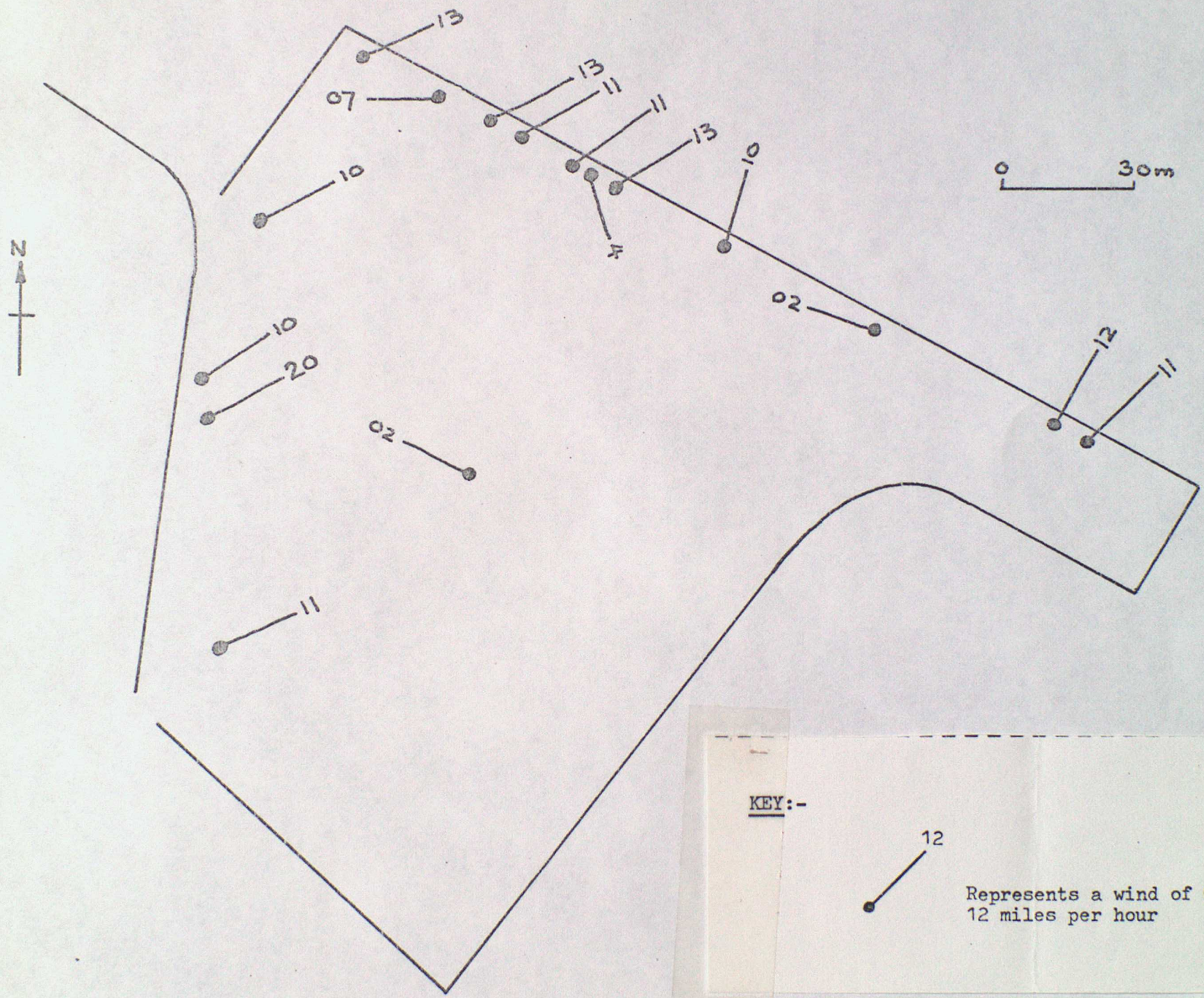


FIG. 7 - Wind Direction and Speed from Woelfle Record at Site 1 at Time of birth.

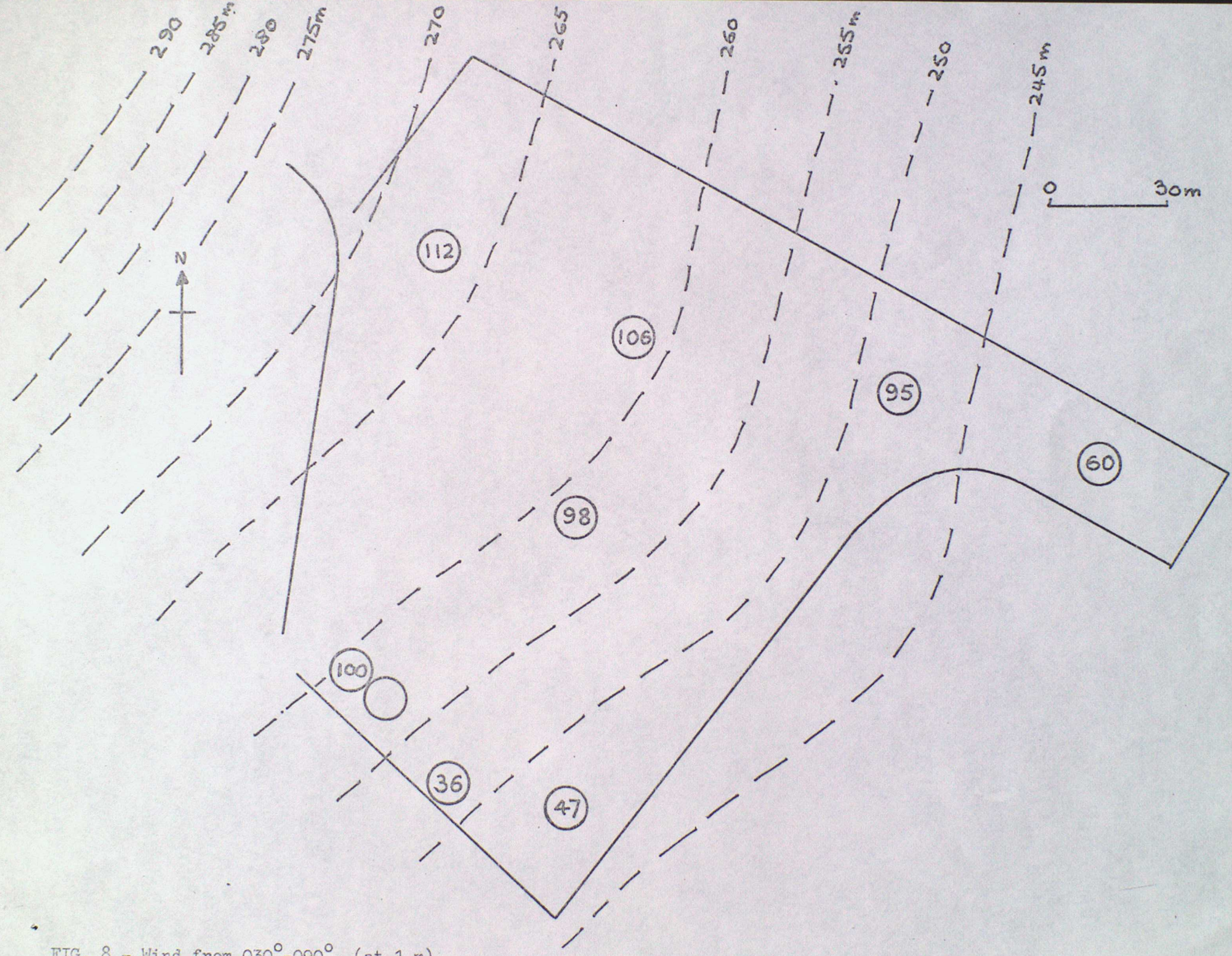
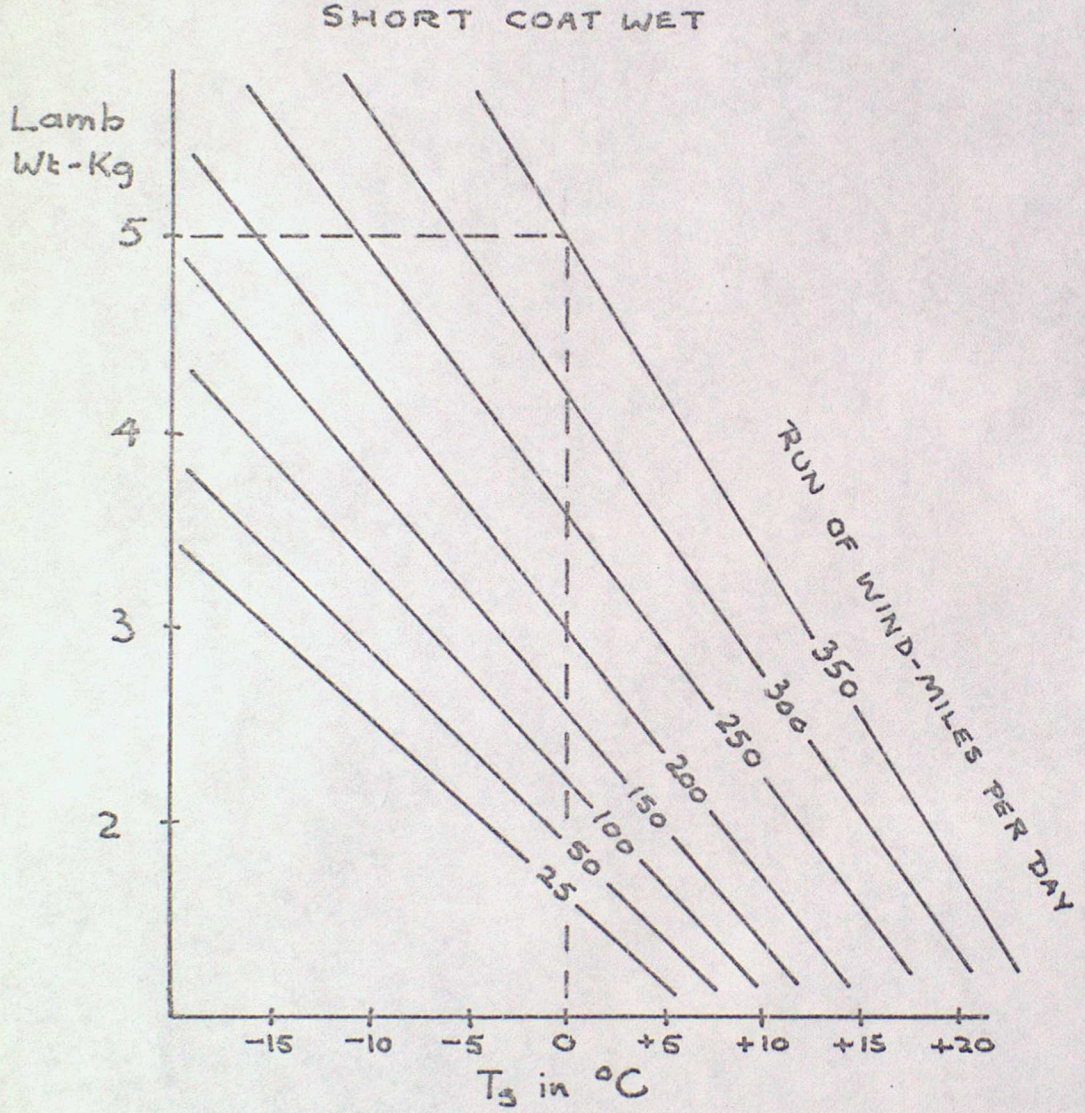
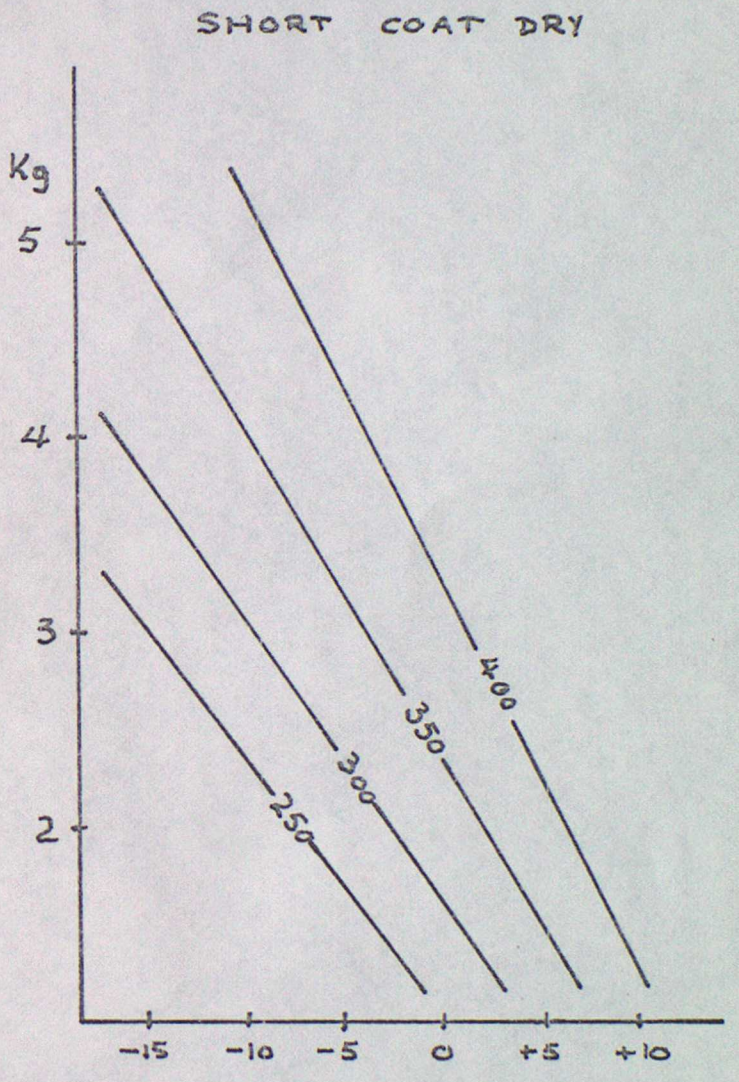


FIG. 8 - Wind from 030°-090° (at 1 m)





Example - For a young lamb, weight 5 kg with wet coat in a wind of 350 miles/day $T_s = 0°C$

FIG. 9 - Calculation of T_s (Deduced from Alexander)